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Swerts, M.G.J.; Krahmer, E.J.

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Meaning, Intonation and Negation

Marc Swerts and Emiel Krahmer

(1) Communication and Cognition, Faculty of Arts, Tilburg University, The Netherlands

(2) CNTS, Center for Dutch Language and Speech, University of Antwerp, Belgium

Abstract. This paper describes a methodology for the study of meaning and intonation, focusing both on what speakers can do (using production experiments) *and* on what hearers can do (using perception experiments). We show that such an experimental paradigm may yield interesting results from a semantical point of view by discussing the role intonation can play in the interpretation of negation phrases in natural language. We present empirical evidence for the existence of a set of prosodic differences between two kinds of negation, descriptive and metalinguistic. This distinction has been the subject of considerable debate in presupposition theory and also plays an important role in discussions about the division of labor between semantics and pragmatics. In general, we argue that intonation gives rise to 'soft constraints', and point out that an optimality theoretic framework may be suitable to model the relation between intonation and meaning. We outline some problems and prospects for an optimality theoretic account of meaning and intonation.

Keywords: Intonation, negation, production and perception, optimality

1. Introduction

1.1. Meaning, Intonation ...

In describing the sound shape of a language, it is common practice to distinguish between a segmental and a suprasegmental (or prosodic) level. The former refers to the individual speech sounds, seen as the basic units into which a continuous stream of speech can be subdivided. The latter comprises vocal features such as speech melody, tempo, loudness, pause, that are not typical attributes of the single segments, but are characteristic of longer stretches of speech. There has been a lot of research on how these two levels of sound structure may affect the meaning of an utterance. At the segmental level, one can view the individual speech sounds as the basic building blocks out of which meaningful units are constructed. Though they have no intrinsic meaning of their own, they may change meaning in a discrete way, as the replacement of one phoneme by another forms a different word (the distinctivity principle). Consider the following pair of utterances:

(1) a. John likes dogs.
b. John likes hogs.

The difference in meaning between these utterances is obvious. There is a clear-cut segmental contrast between the phonemes /d/ and /h/, which implies a categorical difference between the words *dogs* and *hogs*, and thus accounts for the difference in (truth-conditional) meaning between (1.a) and (1.b). A linguistic description of such phonological contrasts is helped by the existence of a lexicon which provides a yardstick to decide whether or not a difference in form leads to a difference in meaning.

Similar attempts to relate form to meaning at the suprasegmental level have often been less successful, because prosodic variation is usually not distinctive in this structural linguistic sense. It is generally more difficult to paraphrase how the meaning of an utterance is affected by replacing its intonation contour by another. For instance, consider the following variants of (1.a). In (2.a), the word *dogs* is pronounced with a sharp rise in pitch (an H* pitch accent in the terminology of Pierrehumbert 1980), while in (2.b) it is pronounced with a lower-rising pitch accent (notated as L+H*).

(2) a. John likes DOGS
H*
b. John likes DOGS
L+H*

What is the difference in 'meaning' between (2.a) and (2.b)? For instance, what is the function of the L+H* accent in (2.b)? The literature contains the following, partially overlapping suggestions. According to Pierrehumbert & Hirschberg (1990) it marks a contrastive relation between *dogs* and something else. Vallduví (1992) claims that it indicates that the NP *dogs* is a link (an instruction to update a file card, in the sense of Heim 1982). According to the theory of Steedman (2000) it is an indication that *dogs* is part of the theme (provided that the entire contour is of the form L+H* L− H%), while Hendriks (2002) would claim that *dogs* is a non-monotone anaphor. To complicate the picture even further, it is still a matter of considerable debate whether a separately identifiable L+H*-form accent exists.[1]

This is not an isolated problem. When studying the relation between meaning and intonation, we have to face basic questions such as: what are the descriptive intonational units, does the assumed meaning of a

[1] Recent work by Herman and McGory (2002) shows that of all the ToBI tones (Silverman et al., 1992) the H* and L+H* are conceptually the most similar ones, and the main cause of disagreements between professional labellers.

contour generalize to all tokens of that intonation pattern, how should one account for the variability between speakers in how they supplement their utterances with intonation patterns and for the variability between listeners in how they interpret particular contours, and how should one deal with the fact that the linguistic and situational context of an utterance may overrule the meaning of a given intonational contour.[2] Problems such as these made intonologists sceptical about the prospects of assigning 'meanings' (in the broadest sense) to intonation contours. Cutler (1977:106): "(. . .) the attempt to extract from [intonation contours] an element of commonality valid in all contexts must be reckoned a futile endeavour". One of the propositions (no. 9) of the theory of intonation put forward by 't Hart et al., (1990:110) is: "Intonation features have no intrinsic meaning." One of the key problems seems to be that prosody often involves gradient rather than categorical differences, which is a severe complication when one wants to apply the principle of distinctivity to prosodic features, and assign semantic properties to these features.

Despite these methodological difficulties, semanticists are increasingly interested in incorporating intonation in semantic theories of language (e.g., Schwarzschild 1999, Steedman 2002 and Hendriks 2002). The motivation is that utterances do not occur in an intonational vacuum.[3] Rather, speakers may use intonation to cue certain aspects of meaning, and listeners may use these cues during the interpretation of the speaker's utterance. The case of negation phrases offers a good illustration of this.

1.2. . . . and Negation

Negation phrases in natural language are usually represented semantically by a logical negation. But consider the following examples from Horn (1985:132), who uses small caps to indicate pitch accents:

(3) a. Some men aren't chauvinists — all men are chauvinists.
b. I didn't manage to trap two monGEESE — I managed to trap two monGOOSES.

The negation phrases in the first part of these utterances do not negate part of the proposition expressed, but respectively a conversational

[2] Moreover, it is worth stressing that prosody may also be 'meaningful' in quite different ways, to signal communicatively relevant phenomena like the cocktail party phenomenon, turn-taking, emotional and attitudinal aspects of utterances, etc.

[3] This is obvious for spoken language, but recent psycholinguistic evidence suggests that people even use intonation when interpreting *written* language (see e.g., Fodor 2002).

implicature and an instance of inflectional morphology. It is not obvious how negation should be expressed logically for examples such as these. According to Horn (1985:125), the classical examples of presupposition denial are manifestations of the same problem as that exemplified by (3). Consider the standard example, originally due to Russell (1905).

(4) The present king of France is not bald.

In (4) the negation phrase can either deny the proposition that the present king of France is bald or the presupposition that a king of France exists. The difference becomes especially clear when we take a question-answer perspective.

(5) Q: Is the present king of France bald?
A_1: No, he isn't.
A_2: No, the king of France isn't BALD — there ISN'T any king of France.

Horn would call the negation in A_1 a **descriptive** negation and the one in A_2 (like those in (3)) a **metalinguistic** negation. The problem is that we have two different uses of negation, which cannot both be treated in the same logical way.

Various solutions have been proposed. One is to assume that natural language negation is semantically ambiguous. Russell, for instance, maintains that (4) is ambiguous between a narrow scope and a wide scope reading for the negation. Others, following the seminal work of Frege and Strawson, have argued that presupposition failure leads to truth-value gaps (propositions being neither true nor false) and that there should really be two different logical negations (e.g., $\neg$ for the traditional negation, and $\sim$ for the presupposition cancelling negation).[4]

φ	$\neg\varphi$	$\sim\varphi$
T	F	F
F	T	T
N	N	T

The main problem for accounts which assume the existence of a semantic ambiguity for negation is that it is difficult to show the actual

[4] See Beaver and Krahmer (2001) for an overview. They also present an alternative to postulating ambiguities for logical connectives, which uses Bochvar's (1939) assertion operator A as a *presupposition wipe-out device*; whatever is presupposed by a logical formula φ, $A\varphi$ presupposes nothing.

existence of such an ambiguity. For instance, while it is true that there are many languages in which negation may be ambiguous, this ambiguity apparently does not involve two negation phrases which can be represented in the logical form as $\neg$ and $\sim$ respectively. This has led other researches (such as Atlas 1977 and Gazdar 1979) to deny the existence of an ambiguity for negation. However, this is "wielding Occam's razor like a samurai sword" (Horn 1985:126), in that it denies the existence of the two distinct uses of negation.

According to Horn negation is *pragmatically* ambiguous. It has a built-in duality of use; negation may be used in either a descriptive or a metalinguistic way. The difference in usage can be illustrated best when the two types of negation are studied in larger interactions: metalinguistic negation naturally occurs in response to utterances by other dialogue partners earlier in the same discourse contexts, announcing a speaker's unwillingness to accept another's assertion of a particular state of affairs. Thus, following Horn (1985:136), a metalinguistic negation expresses something like "'I object to u", where u is crucially a linguistic utterance rather than an abstract proposition".

The problem, then, is how to distinguish the different uses of negation. Horn mentions two tests. The first is based on the ability of descriptive (but not metalinguistic) negation to incorporate prefixally. These examples are from Horn (1985:140):

(6) a. The king of France is {not happy / * unhappy} — there isn't any king of France.
b { It isn't possible / * Its impossible } for you to leave now — it's necessary.

The second test (mentioned in an appendix of Horn 1985) is based on the observation that metalinguistic (but not descriptive) negation can occur in "not X but Y" contexts. Consider the following example (due to Fillmore, cited by Horn 1985:170):

(7) John wasn't born in Boston, but in Philadelphia.

Both tests are not foolproof and have a somewhat limited applicability, so a more general criterion would be useful. It has been argued that intonation could be used to distinguish the two uses of negation. Some claim that the negative sentence in a metalinguistic negation involves "contrastive intonation with a final rise" (this is what Liberman and Sag 1974 dubbed the 'contradiction contour'[5]) while the continuation contains a 'rectification' which is prosodically marked.

[5] Note that Cutler (1977) has argued that this particular contour can also have very different 'meanings'.

The goal of the current study is to find empirical support for the difference between descriptive and metalinguistic negations. In particular, we present evidence for the existence of a set of prosodic correlates for these two different usages. We focus both on what speakers do (using production data) *and* on what hearers do (using perception data). The perception experiment explicitly trades on the assumption that meaning distinctions are only communicatively relevant if they can reliably and consistently be 'interpreted'. In the following, we will first give more information on the data we used and on the way we operationalized descriptive and metalinguistic negations. Then, we present results of a speaker-oriented and listener-oriented analysis of the negations. We end with a general discussion and conclusion.

2. Data and definitions

How do speakers produce metalinguistic negations, and is there a difference with 'ordinary', descriptive negations? To address this question, we have conducted a corpus study of a set of human-machine interactions that contains utterances that can be operationalized as instances of a descriptive or a metalinguistic usage of negation. Our starting assumption is that the discussion about the two types of negation is very much in line with claims put forward in current models about dialogue behaviour. One central claim in many of these models is that dialogue partners are continuously monitoring the flow of the interaction, and notify each other whenever something is wrong. This is reflected in the following rule for dialogue behavior from Groenendijk et al., (1996):

> **Rule H2** If a sentence is uttered which is incompatible with a participant's information state, then she does not update with it, but signals the incompatibility by uttering a sentence that contradicts the sentence uttered.

We take it that metalinguistic negations are examples of 'sentences contradicting the previously uttered sentence'. They function as a negative, 'go back' signal, indicating that there is an apparent communication problem; a discrepancy between the last utterance of the addressee and the information state of the current speaker. If there are no communication problems, the speaker sends a positive, 'go on' signal. Our hypothesis is that speakers use more prosodically marked features in the case of 'go back' signals (indicating a communication problem) than in the case of 'go on' signals. The intuition is that it is more important for an addressee to pick up a 'go back' signal than it is to pick up a 'go on' signal (see also Clark and Schaeffer 1989). If a 'go on' signal is

missed, this does not hamper the communication; it can continue anyway. The expectation that go-back signals are provided with prominent prosodic features is in line with Horn's claim that metalinguistic forms of negation are 'marked'.

To test the hypothesis a corpus of human-machine dialogues was used.[6] This corpus consists of 120 dialogues with two speaker-independent Dutch spoken dialogue systems which provide train time table information (see Weegels 2002). In a series of questions, both systems prompt the user for unknown slots, such as departure station, arrival station, date, etc. Twenty subjects were asked to query both systems via telephone on a number of train journeys. They had to perform three simple travel queries on each system (in total six tasks). In the corpus used in this study, subjects may use disconfirmations in response to two kinds of questions, of which (8.a) and (8.b) are representative examples.

(8) a. So you want to go from Eindhoven to Swalmen?
b. Do you want me to repeat the connection?

Both (8.a) and (8.b) are yes/no questions and to both "no" is a perfectly natural answer. However, the two questions serve a rather different goal, and consequently the corresponding negations have a rather different function. Question (8.a) is an (explicit) attempt of the system to verify whether its current assumptions (about the departure and arrival station) are compatible with the intentions of the subject.[7] If this is not the case, the subject will signal this (in line with rule H2 above) using a metalinguistic negation, thereby indicating that at least one of the system's assumptions is incorrect:

(9) No, not to Swalmen but to Reuver.

(Compare example (7) above.) Question (8.b), on the other hand, is not an attempt of the system to verify its assumptions, and hence it cannot represent incorrect system assumptions. A subsequent negative

[6] The current discussion of negation is part of a wider research programme to study communication problems in human-machine conversation (see e.g., Krahmer et al., 2002). Given the current state of the art in speech technology, spoken communication with computers is still error-prone. Moreover, computers find it difficult to monitor the ongoing dialogue. If they would be able to distinguish descriptive negations (which do not signal communication problems) from metalinguistic negations (which do), this would be helpful from an error-handling point of view.

[7] Due to the imperfections of automatic speech recognition technology, current state dialogue systems are in constant need of verification.

answer from a subject thus serves as an 'ordinary', descriptive negation. A typical example would be:[8]

(10) No, that is not necessary.

So, the two kinds of system yes/no questions allow for an unambiguous distinction between descriptive and metalinguistic negation. The respective disconfirmations, being lexically similar but functionally different, constitute minimal pairs, allowing us to check whether the various occurrences of this kind of utterance vary prosodically as a function of their context. In this way, they form ideal, naturally occurring speech materials for investigating the role of prosody, which can be analysed both from a speaker and listener perspective, as will be illustrated in the following sections.

3. Experimental analyses

3.1. Speaker's Perspective: Production Experiment

3.1.1. *Method*

To study the speaker's perspective we randomly selected 109 negative answers to yes/no questions from the 120 dialogues. If a negative answer follows a verification question (such as (8.a)), the subject's utterance indicates that there are communication PROBLEMS. This is the case for 68 of the 109 negative answers (62%). If a negative answer follows a standard yes/no question (like (8.b)) there are no communication problems (notated as NO PROBLEMS). These are the remaining 41 cases (38%).

Regarding their structure, the subjects' negations were divided into three categories: (1) responses only consisting of a single explicit disconfirmation marker "no" ("nee"), (2) responses consisting of an explicit disconfirmation marker followed by other words ('no+stuff' in the terminology of Hockey et al., 1997), (3) responses containing no explicit disconfirmation marker ('stuff').[9]

[8] The original Dutch utterance is *Nee, dat is niet nodig*, and —significantly— the negation phrase could also have been incorporated prefixally (*Nee, dat is onnodig*) Compare example (6) above.

[9] As we shall see, metalinguistic negations may occur which do not contain an explicit negation. An example would be the second turn in the following exchange:

A: Thomas ate some cookies.

B: He ate ALL cookies!

Table I. Numbers of negative answer types following an unproblematic system utterance (NO PROBLEMS) and following those containing one or more problems (PROBLEMS).

Type	NO PROBLEMS	PROBLEMS	Total
no	18	11	29
stuff	0	24	24
no+stuff	23	33	56
Total	41	68	109

The subjects' responses to the yes/no questions were analyzed in terms of the following features: (1) presence or absence of a high boundary tone following "no"; (2) duration (in ms) of "no"; (3) duration (in ms) of pause after "no" before stuff; (4) duration (in ms) of pause between system's prompt and user response; (5) F_0 max[10] (in Hz) at energy peak of major pitch accent in stuff; (6) number of words in stuff.

3.1.2. *Results*

Table I gives the distribution of different types of negation following either an unproblematic system utterance or one which contains one or more problems. A χ^2 test reveals that these numbers significantly differ from chance level ($p < 0.001$). First, this table shows that the minimal response, a single no, is in the majority of the cases used when there are no communication problems. Second, single stuff responses are exclusively reserved for responses following a system utterance with one or more problems. The majority of the responses to yes/no questions in our data, however, is of the no+stuff type, which may serve either as a descriptive or as a metalinguistic negation. The lexical material in the stuff is quite different for the two signals: for the positive cases, the subsequent words are mostly some polite phrases ("thank you", "that's right"); for the metalinguistic cases, the stuff usually is an attempt to correct the information which caused the problems (i.e., what Horn called the 'rectification').

Table II displays the presence or absence of high boundary tones (H% in the terminology of Pierrehumbert 1980) on the word "no" (for the single no and no+stuff cases). A χ^2 test reveals that this distribution is again well above chance level ($p < 0.001$). In the case of problems, the "no" is generally provided with a question-like H%

[10] F_0 stands for *fundamental frequency*; changes in the fundamental frequency are the most commonly used approximation of perceived pitch variations.

Table II. Presence or absence of high boundary tones following occurrences of "no" (single no and no+stuff, 29 and 56 cases respectively) for positive and negative cues.

High boundary tone	NO PROBLEMS	PROBLEMS	Total
Absent	32	7	39
Present	9	37	46
Total	41	44	85

Table III. Average values for various features. Duration of "no" (for all occurrences of "no": single no and no+stuff), delay between end of system utterance and beginning of user's disconfirmation (all cases), pause between "no" and stuff (for no+stuff cases), F_0 max in stuff and number of words in stuff (both for no+stuff and stuff).

Feature	NO PROBLEMS	PROBLEMS
Duration of "no" (ms)**	226	343
Preceding delay (ms)**	516	953
Following pause (ms)*	94	311
F_0 max in stuff (Hz)*	175	216
Words in stuff**	2.61	5.42

$^{**}p < 0.001$, $^{*}p < 0.05$

boundary tone, which is absent when "no" follows an unproblematic system utterance.

The results for the continuous prosodic features of interest are given in Table III. Taking the utterances of all subjects together, a t-test reveals a significant difference for each of these features. The trend is the same in all cases: corrective, metalinguistic negations are comparatively marked. First, the word "no" —when it occurs— is longer. Second, there is a longer delay after a problematic system prompt before subjects respond. Third, in the no+stuff utterances, the interval between "no" and the remainder of the utterance is longer. Fourth, the stuff part of the answer usually contains a high-pitched accent to mark corrected information, whereas in the unproblematic case the stuff is usually prosodically unmarked. Finally, the stuff part tends to be longer in number of words. In sum: there are clear prosodic differences between metalinguistic and descriptive negations.

3.2. Hearer's Perspective: Perception Experiment

3.2.1. *Method*

It seems a reasonable hypothesis that when speakers systematically dress up their utterances with certain features, hearers will be able to attach communicative relevance to the presence or absence of these features. To test if this is indeed the case for the acoustic properties of utterances of "no" described in Section 3.1, a perception experiment was carried out. For this experiment we used 40 "no"s, all taken from no+stuff disconfirmations. We opted for no+stuff disconfirmations since these are the most frequent. In addition, they are equally likely to be used following problematic and unproblematic system utterances from a distributional perspective (see Table I), and are thus least biased in terms of their function as positive or negative cues. For the perception study, we only used the "no"-part of these utterances, given that the stuff-part would be too informative about their function (compare answers A_1 and A_2 in (5)). Of the 40 "no"s, 20 functioned as a descriptive negation and 20 as a metalinguistic negation. Subjects of the perception experiment were 25 native speakers of Dutch. They were presented with the 40 stimuli, each time in a different random order to compensate for any potential learning effects. They heard each stimulus only once. The experiment was self-paced and no feedback was given on previous choices. In an individual, forced choice task, the subjects were instructed to judge for each "no" they heard whether the speaker signaled a communication problem or not. They were not given any hints as to what cues they should focus on. The subjects were first presented with four "exercise" stimuli to make them aware of the experimental platform and the type of stimuli. It is worth stressing that the choice to use only "no"s extracted from no+stuff answers implies that not all the acoustic features which speakers employ (see above) survive in the current perceptual analysis. In particular, we lose the features delay (time between end of prompt and start of subject's answer), pause (time between end of "no" and beginning of stuff) as well as any potential cues in the stuff part (e.g., number of words, narrow-focused pitch accents).

3.2.2. *Results*

Table IV summarizes the results of the perception experiment. For each stimulus, a χ^2 test was used to check whether there was a significant preference for perceiving an utterances as signalling NO PROBLEM or as signalling a PROBLEM. Of the descriptive negations, 17 out of 20 were classified by a significant number of subjects as cases in which the speaker did not signal a problem. The remaining three cases were

Table IV. Perceived classification of positive and negative signals.

	Perceived as NO PROBLEMS	No significant difference	Perceived as PROBLEMS	Total
NO PROBLEMS	17	3	0	20
PROBLEMS	1	4	15	20
Total	18	7	15	40

in the expected direction, though not significant. Of the metalinguistic negations, 15 out of 20 cases were classified correctly as instances of "no" signaling problems. Interestingly one metalinguistic negation was significantly misclassified as a descriptive negation. A post-hoc acoustic analysis of this "no" revealed that it shared its primary characteristics with ordinary descriptive negations. In particular: the "no" was relatively short, and lacked a high boundary tone. Table IV clearly shows that subjects are good at correctly classifying instances of "no", extracted from no+stuff utterances, as descriptive or metalinguistic negations.

4. Discussion: Meaning, Intonation and Optimality

We have studied the differences between two kinds of negation, descriptive and metalinguistic, and did so from two perspectives. The production perspective showed that there are a number of significant prosodic differences between the two. Metalinguistic negations tend to have high boundary tones (in line with Liberman and Sag 1974), the negation phrase itself is relatively long, is preceded and followed by longer pauses and the continuation has a relatively high pitch peak. This pitch peak is placed on the corrected item (the rectification) and has a narrow focus. A typical example is the following, in which the speaker indicates she doesn't want to go to Amsterdam:

(11) No, to OPdam.

It is interesting to observe that the pitch accent occurs on the syllable 'op-', while normally it would occur on '-dam'.

Descriptive negations, on the other hand, are usually not realized with a high boundary tone, are preceded and followed by shorter pauses, and have a relatively flat continuation (in the no+stuff cases). In addition, it is interesting to observe that a single negation 'no' is most

likely to be descriptive, while single stuff is exclusively associated with the metalinguistic case. Thus, it appears that speakers produce metalinguistic and descriptive negations in prosodically different ways.

The perception experiment confirmed this, in the sense that hearers were quite capable of predicting whether the word 'no' signalled a problem or not (i.e., whether it was used metalinguistically or descriptively). They could do this with utterances which display only a small subset of the relevant prosodic features, and without contextual or lexical information. These findings are interesting from a semantic point of view: they give people who assume that negation is ambiguous (be it semantic or pragmatic) an empirical argument for postulating such an ambiguity. It has been noted that other constructions (such as conditionals, questions, etc.) can also be used metalinguistically. Consider the following examples (from Beaver 1997 and Horn 1985, respectively):

(12) a. If Mary KNOWS that Bill is happy, then I'm a Dutchman — she merely BELIEVES it.
b. You did WHAT with Sally and Billy?

We conjecture that some of the intonative properties which distinguish metalinguistic from descriptive negation can also be found in other metalinguistic phenomena.

The relation between meaning and intonation is a highly complex one. We have argued that to investigate this relation an experimental approach is called for, in particular one in which both the speaker's perspective and the hearer's perspective are taken into account. One obvious methodological advantage of doing experiments with different speakers and listeners is that one gains insight into inter- and intra-subject agreement, both in terms of production and perception, and that it provides a handle on how to deal with the intrinsic variability between subjects regarding intonational matters. In addition, it is instrumental in determining what is essential (that which many subjects agree on) and what is peripheral (those features regarding which there is little consensus). It is difficult to imagine how this distinction can be made on the basis of researchers' intuitions alone. It should be pointed out that this methodological approach combining production and perception studies is very general. For instance, we have also applied it to the study of differences in accent types (Krahmer and Swerts 2001) and in a cross-linguistic study of focus (Swerts et al., 2002).

The motivation for looking both at speakers and listeners is that it does justice to our belief that a feature can only be communicatively relevant if it is not only encoded in the speech signal by a speaker,

but can also be interpreted by a listener. There is an interesting parallel with Optimality Theory (OT) here; OT syntacticians tend to focus on the speaker perspective, while OT semanticists (such as Hendriks and de Hoop 2001) tend to focus on the hearer. Recently, there has been an increased interest in combining the two perspectives (see e.g., Beaver 2004 for such a plea). In fact, we believe that an OT-like framework is eminently suitable to model the intricate relationship between intonation and meaning.

First of all, it is clear that whatever meaning intonational contours may have, they can easily be 'overruled' by features from other linguistic levels or by the situational context. This has, for instance, been illustrated by Geluykens (1987) who showed that the classification of intonation contours as statements or questions is influenced to a high extent by the lexical content of the utterances on which they occur.

(13) a. You feel ill.
b I feel ill.

He tested this perceptually using sentences with a declarative syntax, finding that high-ending contours are more likely to trigger an interrogative interpretation if they occur on question-prone utterances like (13.a) than on statement-prone utterances like (13.b). This difference can be explained by the observation that it is easier to make statements about one's own internal state than about those of other people.[11] Or consider an utterance like

(14) You fucking idiot.

spoken to the driver of a car that just hit the speaker's car. Whatever contour the speaker would put on that utterance, it will be difficult to seriously affect its intended basic meaning. In this paper, we have seen that user responses to communication problems contain prosodic but also non-prosodic cues, like the lexical material in the stuff part of the no+stuff utterances. These cues may even conflict, as shown by the particular example of the single metalinguistic negation consistently classified as a descriptive negation (see Table IV); even though the prosodic features of "no" suggested that there were no communication problems, this is overruled by the lexical material in the stuff ("not to Amsterdam, to Opdam!").[12]

[11] See e.g., Beun (1990) for an alternative analysis in terms of shared knowledge and Safarova and Swerts (2004) for further discussion.

[12] An open research question related to this would be how *non-categorical* features can be integrated in an OT approach. In principle OT constraints are universal re-

Note that for an OT approach which has something interesting to say about the relation between intonation and meaning, it is essential to integrate different levels of linguistic analysis into a single tableau. A plea for such an integrated approach can also be found, albeit for different reasons, in Beaver (2004), who notes that one of the main advantages of OT is that it provides us with a new way of looking at the syntax-semantics-pragmatics interface and enables us to make the interconnections between these components explicit using relational constraints.

A final interesting aspect of OT is that it offers a handle on intonational variation across languages. The idea is that many of the OT constraints are universal, although the ranking may differ across languages. We conjecture that the usage of marked prosodic features to signal communication problems is a universal phenomenon. Similar effects have been found in quite different types of human-human and human-machine interactions, collected for Japanese (Shimojima et al., 2002) and American English (Swerts et al., 2000).

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strictions (e.g., "all feet are right-aligned with the right edge of the word", McCarthy & Prince 1993). However, as shown here, some aspects are of a scalar nature, such as gradient differences in duration and pauses. Moreover, the more features apply, the stronger the semantic effect. Our view is that it may be possible to connect scalar values to differences in constraints (see also Boersma 1998 and Boersma and Hayes 2001). For instance, prominence judgments seem to be gradient in that some differences in pitch range and loudness represent differences in cue strength, which influences the perception of accents, though it is unclear whether the gradient information is truly continuous or whether those types of continua can be divided into reliable categories which are invariant across speakers.

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